Available online at www.sciencedirect.com

ScienceDirect

Procedia CIRP 17 (2014) 818 – 823

www.elsevier.com/locate/procedia

Variety Management in Manufacturing. Proceedings of the 47th CIRP Conference on Manufacturing Systems

Study on impact of CAD / CAM tools on production of punched cards by Indian silk saree designers for handloom industry

K. Shanmuga Sundaram[a], M. Prakash[b]*

[a]*Associate Professor, Department of Mechanical Engineering, Anna University, Chennai – 600025, India*
[b]**Department of Mechanical Engineering, Anna University, Chennai – 600025, India*
[b]* Corresponding author. Tel.: +91 9941168909; *E-mail address:* om.kvm.prakash@gmail.com

Abstract

This report an overview on the use of CAD/CAM in Indian textile industry and their impact specific to silk saree designers. Jacquard mechanism is used to create design on silk sarees by means of shed formation. The jacquard machine has been using chain of punched cards laced together in sequence in silk saree weaving, since its invention in 1801 to till date. The punched cards which carry the design of the saree has been prepared manually and controlled manually till date by Indian silk saree designers. Recently a new system has been emerged in Indian market to completely mechanize the entire process of silk weaving. The design for silk sarees can be generated using a CAD system and later design generated may be directly machined on punched cards by means of CAM and finally the entire cards be joined together in sequence using a lacing machine. These cards are then used to operate Jacquard machine. The effectiveness of this newly implemented CAD/CAM system in production of punched cards and without CAD/CAM is studied.

Selection and peer-review under responsibility of the International Scientific Committee of "The 47th CIRP Conference on Manufacturing Systems" in the person of the Conference Chair Professor Hoda ElMaraghy"

Keywords: Jacquard; weaving; silk saree; punched cards; automation;

1. Introduction

Total export earnings of silk items for India in the year 2011-12 are US$ 491.10 and also it is continues to be US$ 423.37 (Provisional) for the year 2012-13 [1]. This statistic show the significance of silk fabrics in Indian economy. Most of this silk are used to produce sarees. India is also the largest consumer of silk in the world. The tradition of wearing silk sarees in marriages by the brides is followed in southern parts of India. Handloom forms a precious part of generational legacy and exemplifies the richness, which has been kept alive by skilled weavers and designers engaged in the age-old tradition of weaving. The designers with their skilful blending of myths, faiths, symbols and imagery provide their fabric an appealing dynamism. Their strength lies in innovative designs, which cannot be replicated by the powerlooms. It is second only to agriculture sector in terms of providing employment in India. This sector contributes nearly 15% of the cloth production in the country. Nearly 95% of the world's hand-woven fabric comes from India [2]. The main objective of this article is to study the working methodology of Indian handloom silk saree designers and the impact of newly introducing CAD/CAM technologies in pattern making on saree fabrics.

1.1. Elements of jacquard shedding

A jacquard shedding motion is used in weaving designs which consists of more than about 24 different orders of interlacing [3]. In practice, jacquards are mainly used for large and intricate figured designs with several hundreds, or even several thousands, of ends working in different fashion and repeating upon a similar number of picks. An additional advantage is the simplicity of the draft of the warp threads and the fact that the draft does not, as a rule, require altering when the design is changed.

Selection and peer-review under responsibility of the International Scientific Committee of "The 47th CIRP Conference on Manufacturing Systems" in the person of the Conference Chair Professor Hoda ElMaraghy"
doi:10.1016/j.procir.2014.02.045

1.2. Principle of operation

The work of designer is to transfer his design from squared paper to punched cards in the form of holes and blanks. A hole indicates a lift of an end and is, therefore, corresponding with a mark on design paper; and, by reverse, a blank indicates a fall of an end into the bottom shed line and is equivalent to a blank in design paper. One card controls the selection of all the ends in the cloth for one pick. Although the jacquard machines are distinguished into different types, the principle of operation is unchanged in all of its types. The core invention of the Jacquard loom was a clever mechanism that automated the use of punched cards, which made it possible to encode more complex weaving pattern into the operation of a loom. From this mechanism, one can easily guess that overall credits of jacquard mechanism rely mainly on its punched cards which are produced by skilled designers.

2. Production of punched cards

Designers must know the (i) influence of the texture upon the weaves and the fabric, (ii) the arrangements of the threads in the dents of the reed, (iii) the different systems of tying-up the jacquard harness, and (iv) the stamping or punching of the jacquard cards for the various kinds of textile fabrics. The steps involved in the entire process the production of punched cards by conventional method is shown in fig.1. It comprises of numerous operations. The integration of CAD/CAM system into the production of punched cards has enabled to reduce the total processes involved in production. This is enumerated in fig.2. However the three major categories common to both these methods can be classified as

2.1. Sketching of design on squared paper
2.2. Card cutting or Card punching and
2.3. Card lacing

2.1. Sketching of design on squared paper

In Convention, the first work to be done is making an original design, or reproducing a design from temple sculptures, famous rugs, tapestries, alter cloths, etc., and prepare the sketch. If the design is a reproduction from fabric, a correct duplicate on the regular drawing paper is required. In preparing the original sketches, the points to be considered are;

- The setting of figure: some of the commonly used figure sets are symmetrical, half drop, half reverse and combination of both half drop and half reverse etc.,
- Size of sketch required: this is regulated by number of harness-cords in one repeat of design (i.e. total number of hooks present in jacquard machine) and the method of tie-up employed.

Having obtained a perfect sketch of the design as it appears in the original material, or as it is desired to show, the outlines are transferred to the squared designing paper. This squared designing paper consists of number of small rectangles or squares, horizontal and vertical, within a certain distance by a heavy line. The spaces between the vertical lines indicate the warp – threads, and those between horizontal lines, the weft – threads. Designer should have care in selecting correct type of squared paper for particular type of design. Transferring sketch on squared paper always requires an enlargement of

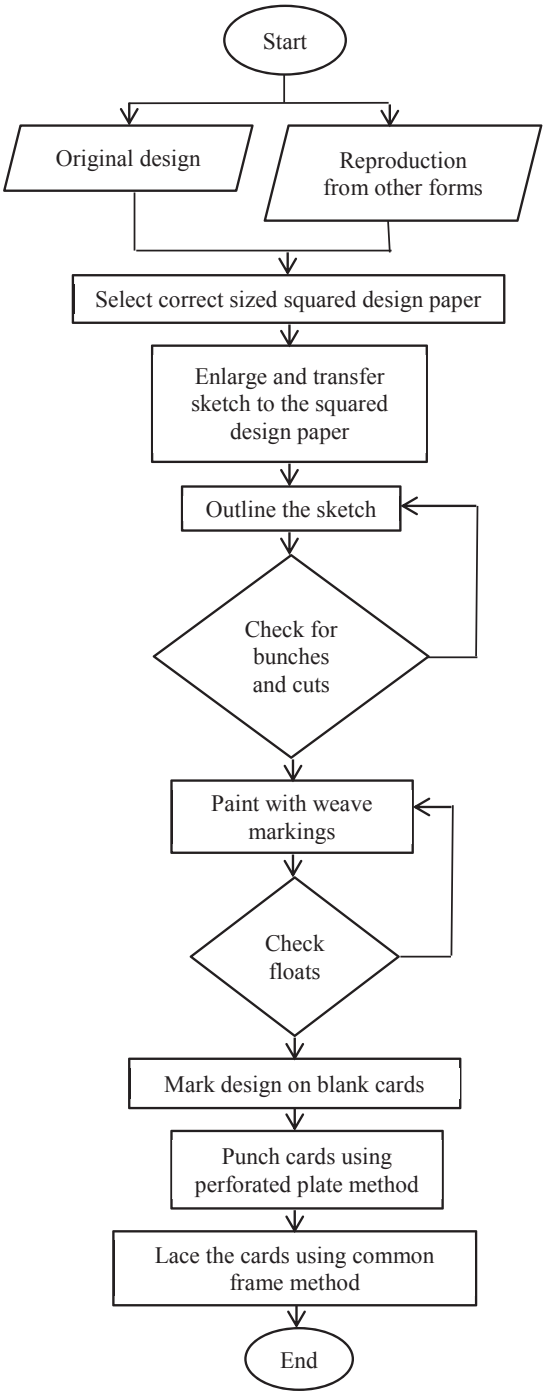

Fig. 1. Production of punched cards by conventional method

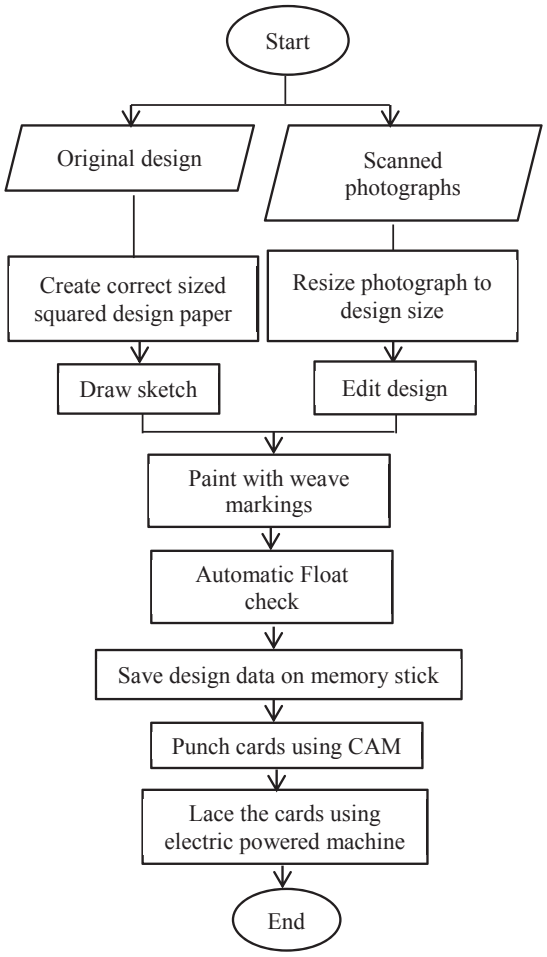

Fig. 2. Production of punched cards by CAD/CAM method

the design, and to accomplish this, the sketch itself must be ruled proportionally to the heavy squares found on squared designing paper.

After the design is transferred to the squared designing paper, it must be outlined in squares. This consists in painting the small squares forming the outline of the figure as called for by the outline of the drawing. Two methods used to form squares are: (i) 'outlining in squares inside the drawing outline' and (ii) 'outlining squares outside the drawing outline'. The most difficult part in outlining to squares is, to obtain the nearest possible reproduction of the drawing outline. If circles, curves etc., are to be made, they must be reproduced as nearly as possible, and no bunches cuts, etc., should disturb its symmetry. After painting the design with proper weave markings, it is ready for card stamping. Fig.3. shows the typical sketch of the design on a squared paper. Some difficulties in traditional method are:

- The drawings have to be again converted as marks on blank cards for punching
- Weave markings and floats should be checked and made with utmost care, as it controls the penetration of picks inside the warps
- Lot of time consuming and requires an extremely talented artist

The difficulties in traditional method can be reduced by introducing state-of-the-art technology into this field. Presently various kind of computer aided software tools are available in market, that specially design silk saree designs. The working of these systems has been natural extensions of the manual designing processes [4-6]. These softwares are devised in a modular structure considering technical and commercial needs of each and every customer. The use of CAD software has enabled to eliminate the process of marking the design pixel on blank cards.

Computer aided design tools offers a suite of CAD/CAM solutions for the designers from concept through design, handling the pre-production requirements and integrating modern machines and ensuring smooth and efficient production of silk sarees. The use of CAD/CAM has thus reduced time, saving costs and improved market response time. Another foremost benefit is that, they help handloom industry is upgrades to latest trends in Textile design and with the use of computer technology.

Some of the widely used CAD/CAM systems are: NedGraphics (Texcelle/Jacquard Pro), CadVantage Win Jacquard, LECTRA (PrimaVision Weave), Pointcarré, Arahne (Arah Weave), Tukatech (TukaStudio), etc., However MS Paint of MS window is used as the default drawing accessory for simple jacquard graph designing software to prepare graph design [7]. Some of the salient features of all these tools are:

- New design creation in a blank graph paper or editing a scanned photograph of any kind of design, from simple to intricate
- Layer concept makes extra warp/weft and multi-layer designing easy with hundreds of sophisticated editing/retouching tools like auto outline, bandhani,

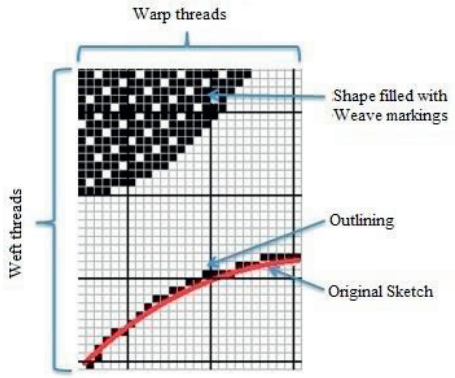

Fig. 3. Typical sketch of the design on a squared paper

etc. with multiple Undo & Redo functions
- Face & reverse view of graph and front & back view of cloth simultaneously with capability to save any kind of motif as a weavemark
- Binding of floats colour-wise/area-wise automatically or manually
- Weaving of photo realistic images of portraits and scenery on fabrics within seconds using dithered weave filling
- Different kinds of outputs like Weaved Graphs for manual Jacquard Card Punching, Electronic outputs to feed Electronic card punching machine of electronic Jacquards directly or Other Printouts like Punched Cards & Weave Parameters are can be generated
- Jacquard weaves can be loaded or saved as different picture formats like TIFF, GIF, BMP, PCX, PNG, etc., which helps in making transition or for easing work in diverse environment

2.2. Card cutting or card punching

In olden days, cards were cut with two perforated steel plates punched by hand using punches. It is extremely tedious and time consuming. Later machines introduced for arranging the punches [8]. Dobby card punching machines, Piano card stamping machines and Repeating machines were the industry used. However, still the Indian designers practice oldest technique of perforating steel plates. The CAD/CAM solution providers all over the world offers electromagnetically controlled punching machines for all types of jacquard cards. Many IT based company like Teckmen Systems, Lectra, Fancy Textiles, Viable Systems Inc., Tex Software, Schleicher, etc., have developed electromagnetically controlled software-hardware systems for automatically punching the cards for jacquard faultlessly from the created design to solve the continuing problems of unreliable, labour oriented, slow and error prone process of manual card punching. Some unique features of electromagnetic systems are:

- High-speed cutting of all types of jacquard cards
- Manual / Automatic feed with sensors to detect card bin empty and card size setting
- Easy to use software for card cutting with features like repeat card cutting, testing, etc.,
- Hooks supported -- 120, 240, 256, 400,600, 800, 1200 or as required with custom diameter of punch and pitch to suit any jacquard
- Complete feedback control and adapt to all kind of CAD tools used in textile industry

2.3. Card lacing

Two types of lacing methods are used in common. They are hand lacing on a common frame and lacing by electric powered machine. In the first method the cards are put on a common frame containing its surface pegs of corresponding sizes to those used on the cylinder. The pegs on the frame are made of hard wood, and the pegs on the cylinder of brass. These pegs on the frame are located at exact distances apart, and the frames are built to hold from 30 to 50 cards, superficially arranged. This enable the serially arranged cards to be laced by a labour manually using thread.

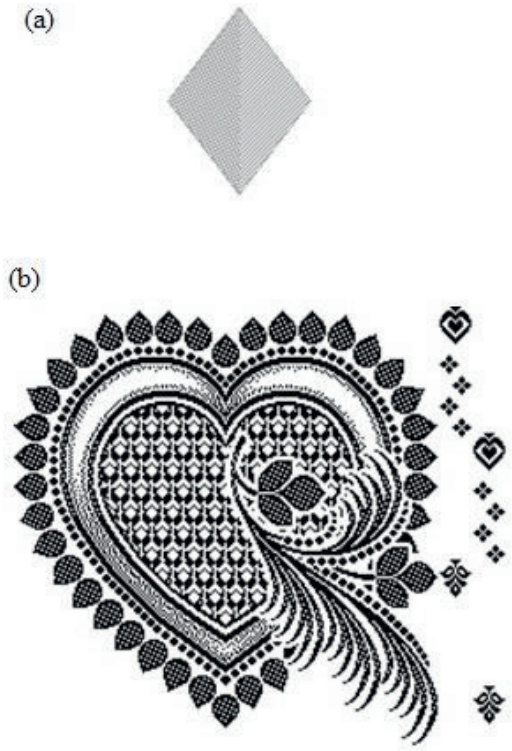

Fig. 4. (a) simple design; (b) complex design

Different types of machines are constructed for lacing of jacquard cards using electric power. These machines consist of one needle and two sets of thread bobbins for each series of lacing holes present in the punched card. Punched cards are fed on the peg hooks, and passes through needle and bobbin arrangements. 'Teckmen systems' are one of leading manufacturer of these kind of lacing machines. These machines are best suitable for mass productions. Still they are not fully automated and need manual feeding of cards at correct location. Time saved by using electric powered lacing machine over common frame method has been studied in this work for hook series of 240.

3. Results and Discussion

To demonstrate the advantage in use of CAD tool in Indian textile industry, the present work was carried out using commercially available CadVantage Win Jacquard tool for sketching the designs. This software has capability to process any kind of raster images. Although the software is able to work with different formats *.bmp is used in this work for getting better quality picture. Later this format is converted

into *.flt format and saved in a memory stick. This stored data on a memory stick is used by CAM machine for punching cards. The studies focused only on percentage save in time considering length of the work. Since both CAD and CAM systems do not have facility to calculate time taken by any specific process, Stop watch is used. Table 1. Show the comparison on the time taken by an experienced designer for sketching designs on graphs by both conventional method and using advanced CAD tool (CadVantage Win Jacquard). Two kinds of designs are taken into consideration; one is of simple type, whereas another one is complex as shown in Fig. 4. (a) and (b) respectively. These two figures are drawn for the various sizes of repeat (Ends x Picks) as shown in table 1. From Figures 5. (a) and (b), and table 1, it can be seen that the save in time for simple and complex designs by using CAD tool over conventional method.

From table 1 it can be noted that, the time taken for preparing graph designs are much saved by using specially designed CAD tools available in the market. It can also be established that CAD tools are advantageous to use for larger repeat sizes and complex designs, as compared to simple designs and smaller repeat sizes. This is due to lesser need of editing works required during outline finishing and fewer weave marks. The table 1 also clearly show, that there is substantial percentage save in time when the designers give their preference to use CAD tools over conventional method.

Table 1. Time saved by CAD tool in generating the design

Design type	Repeat size	Time taken (min)		Time saved by CAD tool (min)	Time saved (%)
		Conventional	CAD tool		
Simple	120E x 120P	38	4	34	89.47
Simple	240E x 240P	95	4	91	95.78
Simple	480E x 480P	172	5	168	97.67
Complex	120E x 120P	190	30	160	84.21
Complex	240E x 240P	425	48	377	88.7
Complex	480E x 480P	755	120	635	84.1

Table 2 indicate the enormous time saved by using CAD tools in each and every process carried out during the preparation of design on graph, particularly while preparing weave marks, painting and outlining sketch. On the other hand the process of preparing sketch in the preliminary stage does not pose any save in time. In contrary it has to be noted that painting the sketch is different from preparing weave marks. Initially the painting operation is done for the whole design without considering pattern of weave marks to be deployed on it. Weave markings are done separately once painting is over. Since the weave markings decides the float length of threads on the fabric, much effort has been put in conventional method. Whereas in CAD method, the software program itself intelligently applies weave markings throughout the entire design within a short time. This leads to highest percentage of save in time than other processes.

Table 3 evidently shows the difference in time for both manual and CAM based method of card punching. In manual method, the time consumed mainly depend on the number of holes to be made on the blank cards and on the skill of the labour. As number of holes on card increases, the time to punch the card also increases. The total number of holes in a card merely depends on the pattern of the design to be woven on fabric. For the experimental purpose, the simple and complex type graph designs of size 240E x 240P, drawn already for our study, were considered. CadVantageWin punch compact machine was used to electronically punch the cards from the PC. The input for the machine is stored as *.flt format and saved in the memory stick from the CAD tool.

Table 2. Time saved in each process of sketches of design

Process	Time taken (min)		Time saved using CAD tool (min)	Percentage of time saved (%)
	Conventional	CAD Tool		
Preparing sketch	65	65	-	-
Enlargement of sketch on Graph	38	23	15	39.47
Outlining sketch	145	12	133	91.72
Painting the sketch	20	1	19	95
Preparing weave marks	160	3	157	98.12
Total Time	428	104	324	75.7

Table 3. Time saved by use of CAM tool in production of punched cards

Graph type	Punching method	No. of cards	Time taken (min)	Total time taken (min)	Percentage of time saved (%)
Simple	Manual (Card marking)	240	64	174	90.80
Simple	Manual (Card cutting)	240	110		
Simple	CAM	240	16	16	
complex	Manual (Card marking)	240	265	580	97.24
complex	Manual (Card cutting)	240	315		
complex	CAM	240	16	16	

The total number of cards to be punched for the repeat size is equal to the total number of picks in that repeat i. e. 240 picks in this case. Each card represents one pick of the cloth. Hence, in this case each card will contain maximum of 240 holes. The series of lacing holes and peg hole are punched at both the ends of the cards along with design holes for permitting lacing operation. Manual card punching require marking of symbols on blank cards, as per the design points are present in each and every pixel of the image. These marked symbols represent the correct holes to be punched on a card using perforated plates punching machine. But electronic punching machine does not need any kind of symbol markings on blank cards. It requires only electric power and machine supportable digital format of the image. It completely detaches the process of card marking and thereby its saves much time and cost. As seen from the above table. 3, the total time required for card marking and card cutting are greatly saved by adapting CAD/CAM system for card cutting

over manual method. And also it should be noted that CAD/CAM systems give the constant output independent to the complexity of the designs. It requires only 16 min to punch all 240 cards for both simple and complex designs. But in manual method the total time required to punch all 240 cards is increased by 406 minutes for complex designs over simple design type. As the complexity of the image increases, the total number of holes in the card also increases and causes the scattered alignment of holes on cards. Hence the labour needs to pay more attention on punching these cards. Once the card is punched they are ready for lacing serially according to their numbers. The electric powered lacing machine of

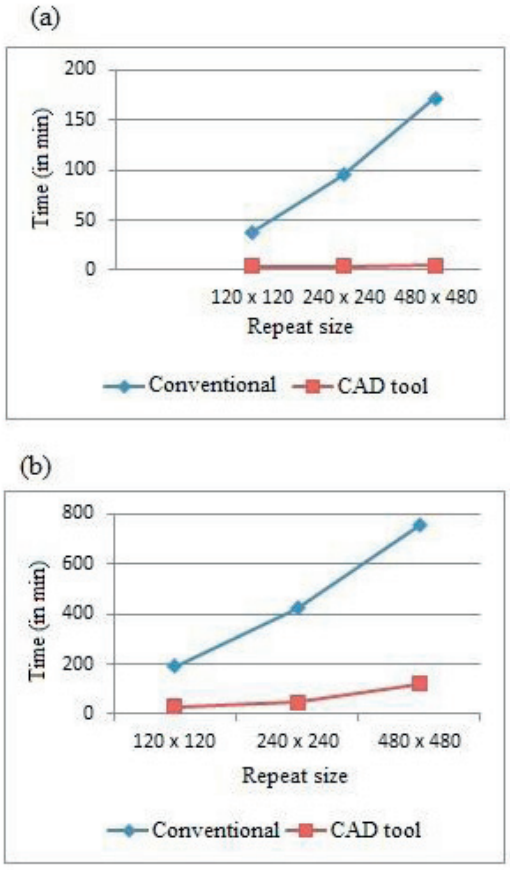

Fig. 5. Time taken vs repeat size for (a) simple design and (b) complex design

Teckmen Systems has been used to carry out lacing operation for this experiment.

Table 4 show, the time taken for lacing a total of 240 cards using common frame and electric powered machine. Since the speed of lacing is purely independent of design complexity, only the punched cards of simple graph design has been considered. It can be inferred from table. 4 that the electric powered machine save time of 86 minutes (81.13 % saving time) over common frame method. Also into account the production output of the machine is constant without taking the machine breakdown time.

Table 4. Time saved by electric powered lacing machine

Lacing Method	Graph size	Time taken (min)
Common frame method	240E x 240P	106
Electric powered machine	240E x 240P	20
Time saved (%)		81.13

4. Conclusion

An overview on the use of CAD/CAM in Indian textile industry and their impact specific to silk saree designers has been reported. Use of jacquard mechanism in pattern making on silk fabrics by means of shed formation is restated in short. Apart from this, use of punched cards in jacquard mechanism and production of these punched cards has been studied and compared between manual method and use of CAD/CAM system. Comparison results show that, there is remarkable saving in time for the production of punched cards. Results also indicate that the production rate during the stages of CAM based ‘card punching’ and ‘card lacing’ are more than that of manual and remain constant irrespective of their type of designs. Whereas during the stage of ‘sketch of design on squared paper’ production time varies with respect to complexity of designs in both manual and CAD/CAM methods. It is also to be noted that CAD/CAM systems provide improved accuracy, reduced labour effort with instant feedback systems for control.

References

[1] Export earnings from silk and silk goods – Central silk board. India. (http://www.csb.gov.in/assets/Uploads/rti-files/item-06-b05.pdf)

[2]Annual report 2012-13. Ministry of Textiles. India. (http://texmin.nic.in/annualrep/ar_12_13_english.pdf)

[3] Z. Grosicki. Watson’s Textile Design and Colour Elementary Weaves and Figured Fabrics, Universal Publishing Corporation; June 1988

[4] Ashis Mitra. CAD/CAM support for jacquard-based textile industry. Indian Textile Journal. October 2011

[5]Mitra A., ‘CAD/CAM Technology offers no-limit solution for textile designing and manufacturing: CAD/CAM module for Dobby Industry’, Asian Textile Journal, 15(7), 80–84, (2006).

[6] Mitra A., ‘CAD/CAM: Ultimate solution for textile excellence’, The Indian Textile Journal, September, 2007; Vol. CXVII, No. 12, 39–44, (2007).

[7] R G Paneerselvam. Use of MS paint for jacquard graph designing and printing. Indian Journal of .Fibre & Textile Research. Vol. 38, June 2013; pp. 186-192

[8] J. K. Raine, K. Whybrew, G. R. Dunlop, C. W. Van Rij, D. K. Ward. Management of Undergraduate Projects with Specific Reference to Redesign of a Jacquard Loom Card-punch System. Journal of Engineering Design. Vol. 8, Iss. 4, 1997;